

PATENT SPECIFICATION

684.3 15



Date of Application and filing Complete Specification: Feb. 18, 1949.

No. 4466/49.

Application made in France on Feb. 19, 1948.

Complete Specification Published: Dec. 17, 1952.

Index at acceptance:—Class 40(vii), DF1p, DP(2x: 5d1:6:x), DR4x, DS2.

COMPLETE SPECIFICATION

Means for Indicating the Angle of Orientation of a Dirigible Craft with Respect to a Desired Path Relative to Ground

We, OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AERONAUTIQUES (O.N.E.R.A.), a Body Corporate organized under the laws of France, of 3, rue Léon Bonnat, Paris 16^e, Seine, France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the problem of guiding of a dirigible craft along a predetermined path with respect to ground by means of signals of radiant or wave energy.

The invention relates more particularly to the problem of the determination and indication on a moving craft such as an aircraft of the angle between its longitudinal axis and its path relative to the ground. In fact, it is necessary in a number of cases and especially in the blind landing of aircraft, to know at every instant the angle, if any, formed by the longitudinal axis of the craft with the path followed thereby with respect to ground.

In the case of a blind landing of an aircraft the latter must follow a straight line the horizontal projection of which must coincide with the axis of the landing strip on which the craft is to land. If there exists at that time a wind having a lateral component with respect to the axis of the landing strip, the aircraft normally advances with its longitudinal axis making a certain angle with the axis of the landing strip in the direction opposing the wind. Accordingly, to effect a correct landing under such conditions, it is necessary to impart to the craft, just before the touch down, a change of direction bringing its longitudinal axis into coincidence with that of the landing strip. To effect such a correction, it is necessary therefore to know the angle formed between said two axes at the

moment just preceding the touch down. This angle in normal visibility conditions may be ascertained directly from the observation of the movement of the craft with respect to ground, but in conditions of blind landing this angle must be determined and indicated to the pilot by special means. Besides, in the case of an automatic landing, it is generally necessary to know completely the position of the craft with respect to the plane of landing, including the angle formed by the vertical longitudinal plane of symmetry of the craft with the vertical plane containing the landing trajectory or glide path.

The present invention consists in a system for detecting angular displacement of the longitudinal axis of a moving body, such as an aeroplane or ship, with respect to a predetermined line of travel toward or away from a given point, comprising radio transmitting means at said point for producing signal radiations in the form of a beam performing a periodic angular movement about said point, in combination with two longitudinally spaced receiving aerials and receiving means on the moving body connected to the respective aerials, said receiving means co-operating with means for indicating the time spacing of the signal radiations received by said aerials in relation to a time base synchronised with the received signal radiations.

The same result can be obtained if, instead of employing signal radiations in the form of a beam performing a periodic angular movement about the given point, synchronously related signal radiations are transmitted from two points symmetrically disposed on either side of the predetermined line of travel, the said signal radiations having a variable characteristic, and if means are provided on the moving body for indicating the algebraic difference of the difference of the variable characteristic as received by

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each aerial on the moving body from the two points in relation to a time base synchronised with the received signal radiations. The invention therefore also
 5 consists in a system for detecting angular displacement of the longitudinal axis of a moving body, such as an aeroplane or ship, with respect to a predetermined line of travel toward or away from a given
 10 point, comprising radio transmitting means for transmitting synchronously related signal radiations having a variable characteristic from two points symmetrically disposed on either side of the
 15 predetermined line of travel, in combination with two longitudinally spaced receiving aerials and receiving means on the moving body connected to the respective aerials, said receiving means
 20 co-operating with means for indicating the algebraic difference of the difference of the variable characteristic as received by each aerial from the two points in relation to a time base synchronised with
 25 the received signal radiations.

The invention will appear more fully from the following description with reference to the accompanying drawings, which illustrate the invention by way of example.
 30 In the drawings, fig 1, 2 and 3 are diagrams illustrating the principle of the invention.

Fig. 4 shows a schematic diagram of
 35 two embodiments of the receiving arrangement to be provided on the craft, and,

Figs. 5, 6 and 7 show three views of the screen of a cathode ray tube oscilloscope
 40 illustrating the indication of the drift compensating angle of the craft simultaneously with distance of the craft to the point of landing and lateral deviations of the craft from the desired path toward
 45 said point.

Referring now to figs. 1 and 2, there is shown a landing strip 1 the axis of which is designated by reference letters X—X. This landing strip is provided at its
 50 remote end with a very high frequency radio beacon of a rotating beam type schematically indicated at 2. Reference numeral 3 designates an aircraft travelling along a path following the axis of
 55 landing X—X with a certain angle of drift compensation α . Aircraft 3 is provided with two spaced aerials M and N arranged at two points on the longitudinal axis and located, respectively, one at the centre of the
 60 wing span of the craft and the other at the rear part of the fuselage. If ϵ be the angle formed by straight lines passing through the two aerials M and N from
 65 radio beacon 2 for an angle of drift com-

pensation α , it appears clearly from the consideration of fig. 2, that by taking into account the value of distance D between the craft and radio beacon 2
 70 which remains always great in comparison to said distance l between the two aerials, the tangent of angle ϵ is equal to the ratio of the normal projection of distance l on a perpendicular to axis
 75 X—X passing through antenna M, to distance D. In view of the smallness of the angle ϵ , considering the distance l between the aerials small compared with the distance D to the beacon, this angle
 80 may be taken as equal to its tangent, and to be considered as substantially equal to $l \sin \alpha$.

As this angle precisely corresponds to the angle swept by the rotating beam when the latter passes from antenna N to antenna M in the example shown, it
 85 is apparent that time $t = \frac{\epsilon}{2\pi\omega}$, required

for the beam rotating with a speed ω to sweep this angle ϵ may serve as a measure of angle α for a given distance D between the craft and the radio beacon.
 90

The measure of time $t = \frac{\epsilon}{2\pi\omega}$ and consequently of angle α may be determined by measuring the time interval between the instants of passage of the rotating beam by the two aerials M and N this
 95 time interval will be nil if angle α is nil and will vary in value in accordance with the direction and the value of angle α formed by the longitudinal axis of the craft and the path followed by said craft
 100 toward a given point.

The indication of the angle ϵ may be obtained by associating, with the two aerials, suitable receiving means
 105 enabling the signal voltages induced in said aerials when the same are successively swept by the rotating beam, to be used for controlling the production of two short duration pulses which may be then compared as regards their relative spacing in
 110 relation to a time base to give the desired indication, said time base being controlled by a reference signal generally an omni-directional signal, defining the instant of passage of the rotating beam
 115 through a predetermined direction making a certain angle with the desired direction of guidance, whereby said pulses are coincident with each other if angle α is zero and spaced one from the other in
 120 one or the other direction as shown in

fig. 3 by a distance $\frac{l^2 \sin \alpha}{2\pi\omega D}$, i.e. a distance

dependent on value $\frac{l \sin \alpha}{D}$ and hence proportional for a given distance D to angle α .

As the distance l is known and the distance D separating the craft from the transmitter may be ascertained, it is possible thus to determine at every moment the exact value of angle α . However, in view of the relatively great value of the distance D compared to distance l , the value of ϵ varies but slightly with the distance D and accordingly for all practical purposes the value of angle ϵ can be taken as a measure of the angle α .

An embodiment of the apparatus which may be used for the purpose of determining the angle with the aid of a rotating beam of radiant energy and two aerials M and N located on the longitudinal axis of the craft, as shown in fig. 1, will be explained with reference to fig. 4, assuming to start with that elements 5, 8², 9², 10² and 19 are dispensed with and that aerials 6 and 7 represent aerials M and N of fig. 1. These aerials are associated with receiving means comprising detectors 8, 8¹, amplifiers 9, 9¹ and differentiators or pulse generators 10, 10¹ the outputs of which are supplied to a mixer 11 which latter controls the action of the grid or control electrode 13 of a cathode ray tube oscilloscope 12. This oscilloscope is provided with vertical deflection plates 14 which remain, in the assumed conditions, ineffective and horizontal deflection plates 15 connected to a time base device 18 triggered by the output of a receiver 17 coupled to an auxiliary aerial 16 adapted to receive a reference signal provided to control said time base device, so that the horizontal sweep is started each time the rotating beam passes through a predetermined position correlated to the desired path to be followed.

In this arrangement, the signals induced by each of the aerials 6 and 7 are transformed, after detection and amplification, into sharply defined short duration pulses, such as shown in fig. 3 and which being applied to grid 13 of the tube 12 produce on the screen of the tube upon each sweep of the rotating beam, two luminous signals such as points or spots differing from each other by their size, colour or brightness and respectively corresponding to front aerial M and to rear aerial N , these two signal points or signs, appearing at the centre of the screen coincide one with the other, when angle α is nil and the axis of the craft coincides with the axis of the landing strip, and one of these points moving to one or the other side of the other point

upon a change of orientation of the craft in one or in another direction when the craft, while following the prescribed path, makes an angle α in one or another direction with said path.

The differentiator arrangements 10 and 10¹ may be advantageously formed by devices of the type described in copending application No. 22601—2—3—4/48 (Serial No. 650,636) whereby the instants of passage of the beam by the respective aerials are sharply defined by short duration pulses produced at a predetermined point of the signal-duration characteristics of the received signals.

The above arrangement may be combined with a distance and lateral displacement indicating equipment of another copending application No. 23866—7/48 (Serial No. 684,313) involving the use of two independent receiving aerials spaced apart transversally to the craft and preferably located at the wing tips thereof, the passage of the rotating beam by said aerials giving rise to short duration pulses used to produce on a cathode ray tube oscilloscope two signal points the relative spacing of which gives the measure of distance and their lateral displacement with respect to a centred position relative to the vertical diameter of the screen indicating lateral deviations of the craft from the desired path.

The measure of the distance obtained with the above method is practically unaffected by any angle α that may be formed by the craft's longitudinal axis and the desired path as in practical cases the angle α does not materially affect the angle subtended from the point of destination by the receiving base line formed by two transversely spaced antennæ, which angle measures precisely said distance.

In such a combination, the signals received by the two pairs of aerials will be effective to produce on the same screen the information necessary to enable the angle α to be computed and the indications of distance and lateral deviations of the craft referred to above.

The measure of the angle α defined hereinabove may be also obtained by the use in combination with two aerials located as previously described on the craft along its longitudinal axis, of a transmission base comprising two synchronously operated frequency modulated transmitters symmetrically located on either side of the axis of the landing strip, as previously described in an earlier application No. 24842—3/48 (Serial No. 684,089).

In such a case, by receiving on each of

said aerials the signals from said two transmitters, one obtains a beat frequency of zero value on one of the aerials and a beat frequency having a particular value on the other of said aerials or else different beat frequencies are obtained on both aerials, this depending on whether the aircraft longitudinal axis is aligned with the desired direction or path with respect to ground or makes a certain angle with said direction or path one of said aerials being on the required line of travel and the other out of the said line or else both aerials being off said line. The algebraic difference between said beat frequencies, which may be considered to be substantially equal to: $\frac{D}{l \sin \alpha}$, so that for a

given distance D, it is proportional to the drift compensating angle α , may serve as a measure of said angle. In this case, also, it is necessary to obtain by separate means distance D between the craft and the transmission base formed by the two transmitters and to introduce into or combine said measure with the above specified indication in order to render said indication independent of said distance.

The angle α may be determined by using on one hand on a craft such as an aircraft three receiving aerials as shown in fig. 2 including two aerials mounted on the wing tips of the craft and an aerial placed on the longitudinal axis of the craft for instance at the rear part of the fuselage and by providing on the other hand on the ground one or more transmitters adapted to transmit radiations presenting a characteristic variable with time and to obtain the measure of the angle α by comparing the effects of reception of said aerials.

A particular embodiment of the above system may be obtained by using in combination with the three receiving aerials such as specified above a very high frequency radio beacon of a rotating beam type adapted to cooperate with the two lateral aerials in accordance with the co-pending application No. 24554-5-6-7/48 (Serial No. 684,314) so that the instants of passage of the beam by said lateral aerials are indicated by short duration pulses adapted to produce on the screen of a cathode ray oscilloscope two luminous signals or points the spacing of which gives the measure of distance of the craft to the radio beacon and lateral displacement of which from a centred position with respect to the vertical diameter of said screen gives an indication of lateral displacement of the craft from the desired path, these points being

further controlled vertically in accordance with the altitude of the craft and related with curves expressing a desired relation between the altitude and distance for effecting a blind landing following a desired glide path. In accordance with the present invention, the third or tail aerial is adapted to cooperate with the system of the above mentioned application so as to provide on the screen of the oscilloscope, between the points indicating the distance, a third luminous signal or point normally occupying a central position for $\alpha=0$ and laterally displaceable from said position according to the sign and the amplitude of said angle α . For this purpose, the tail aerial may be provided with the same receiving means as the two lateral aerials and adapted to control conjointly with said two aerials the cathode ray tube oscilloscope, which also is controlled by an additional receiving aerial adapted to receive a reference signal generally of an omnidirectional type defining the instant of passage of the beam by a direction making a predetermined angle with respect to the desired path or direction to be followed by the craft.

Fig. 4 of the drawings illustrates an embodiment of such an arrangement in which the two lateral aerials are indicated at 6 and 7 and the tail aerial at 5. The receiving means associated with said three aerials comprise respectively detectors 8, 8¹ and 8¹¹, followed by amplifiers 9, 9¹ and 9¹¹ and differentiators 10, 10¹ and 10¹¹. The outputs from the latter are supplied to a mixer 11 the output of which is connected to the grid 13 of a cathode ray tube oscilloscope indicated generally by reference numeral 12. This tube is provided with the horizontal deflection plates 15 connected to a time base device 18 controlled by the reference signal produced when the beam passes through a reference direction making a certain angle with the desired direction of path to be followed by the craft such as the axis of a landing strip, this signal being received by an auxiliary aerial 16 feeding a receiver 17 connected to said time base device 18 to trigger the same. The tube 12 is further provided with a pair of vertical deflection plates 14 adapted to be controlled by an absolute altimeter indicated at 19.

With this arrangement considering first the two aerials A and B of fig. 2 and shown in fig. 4 at 6 and 7, there are produced on the screen of the tube, as is explained in detail in the previously mentioned application No. 24554-5-6-7/48 (Serial No. 684,314) and shown in fig. 5, two luminous points 21 deter-

mined by pulses resulting from the passage of the rotating beam by said two aerials 6 and 7, the relative spacing of said points one from the other giving a
 5 measure of the distance remaining to be flown to a desired point of landing, while lateral displacement of said points with respect to the vertical diameter of the screen indicates angular displacements of
 10 the craft to one or another direction with respect to the vertical plane containing the direction of guidance. As a result of the control imposed on the cathode ray by the absolute altimeter 19, the two
 15 points 21 are further movable vertically in accordance with the altitude of the craft, with reference to a ground line 24. The screen is further provided with two downwardly diverging curves 23
 20 indicating the relation to be maintained upon landing between the altitude of the craft and its distance to the point of landing, in order to maintain the craft on a correct glide path.

25 Considering now the operation of the tail aerial such as indicated at N in fig. 2 and at 5 in fig. 4, the signal induced therein, by the passage of the beam gives rise due to the action of the corresponding
 30 differentiator 10¹¹, to a short duration pulse which, applied to the grid 13 of the cathode ray tube oscilloscope 12, produces a luminous point 22 intermediate the two distance points 21, this point
 35 being equidistant with respect to said distance points 21 if angle α is zero and is displaced laterally toward one or the other of said points depending on the direction and amplitude of said angle, as illus-
 40 trated in fig. 6 and 7.

It is apparent that within the invention the luminous signal or point intended to indicate the drift compensating angle or angle α may be produced in a similar
 45 manner in combination with arrangements of another copending application No. 23866—7/48, in which two signal points such as 21 of fig. 5 are limited in their displacements to a horizontal plane
 50 only, their spacing varying with distance and their lateral displacements indicating deviations of the craft to one or to the other side of the desired direction or axis of landing.

55 The schematic diagram of such an arrangement will be exactly the same as that of fig. 4, except for the control applied by an absolute altimeter 19 on the vertical deflection plates of the
 60 cathode ray tube 12.

65 In a similar way and in accordance with another embodiment of the invention, a luminous point serving to indicate the drift compensating angle may be introduced into another arrangement of

the previously mentioned copending application No. 24554—5—6—7/48 (Serial No. 684,314) in which two distance points on the screen of the cathode ray tube such as 21 on fig. 5 are supplemented
 70 by a third central point adapted to move vertically as a function either of altitude or distance. In this embodiment this third point must be differentiated from the point indicating the drift compensating
 75 angle which may be accomplished for instance by giving to said points different colours or brightness.

In connection with the above embodiments, it is possible to suppress, under
 80 certain conditions, the signal point indicating the drift compensating angle or angle α , as for instance when the distance points such as 21 in fig. 5 come too close to each other or when the alti-
 85 tude of the craft is too great. For this purpose, a tube in the circuit producing the signal point serving to indicate said angle may have its biasing controlled by a potential dependent on the vertical dis-
 90 placement of said distance points, whereby this tube may be biased to cut off if these points exceed a certain elevation on the cathode ray tube screen. The drift angle point will not appear thus
 95 on the screen except when the craft enters in the final phase of blind landing.

The invention provides thus a system and means for determining or indicating
 100 on a dirigible craft its angle of orientation with respect to a desired path followed by said craft. While several embodiments of the invention have been described and illustrated, it is to be understood that the invention is not specifically limited there-
 105 to and that various modifications evident to those skilled in the art may be produced therein without departing from the spirit of the invention.

Having now particularly described and
 110 ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A system for detecting angular dis-
 115 placement of the longitudinal axis of a moving body, such as an aeroplane or ship, with respect to a predetermined line of travel toward or away from a given point, comprising radio transmitting
 120 means at said point for producing signal radiations in the form of a beam performing a periodic angular movement about said point, in combination with two longitudinally spaced receiving aerials
 125 and receiving means on the moving body connected to the respective aerials, said receiving means co-operating with means for indicating the time spacing of signal radiations received by said aerials
 130

in relation to a time base synchronised with the received signal radiations.

2. A system as claimed in claim 1, in which the transmitting means at the given point comprise a radio-beacon producing a rotating beam of very high frequency.

3. A system as claimed in claim 2, characterised by means for producing a reference signal when the beam passes through a predetermined point relative to the predetermined line of travel passing through the point of origin of the beam and means on the moving body for receiving and indicating with reference to a time base the reception of said reference signal.

4. A system as claimed in claim 3, in which a cathode ray oscilloscope is provided for indicating the instants when the aerials are energised by the moving beam, the said oscilloscope being controlled by the reference signal and responding to the signals from the beam received by the respective aerials on the moving body.

5. A system as claimed in claim 4, in which the reference signal triggers the time base of the cathode ray oscilloscope so as to cause the electron beam thereof to sweep along one axis of the cathode ray tube, the signals received by the aerials on the moving body producing luminous signals on the screen of the cathode ray tube the positions of which correspond to the times when the aerials receive the radiations from the rotating beam.

6. A system as claimed in any of claims 1 to 5, in which one of the spaced aerials is located on the longitudinal axis of the moving body and the other on one side of the longitudinal axis, on a common base line longitudinally spaced from the first mentioned aerial with a third aerial located on the other side of the longitudinal axis and connected to receiving means, the receiving means connected to the said aerials co-operating with said indicating means for signal radiations received by said aerials so as to detect the angular displacement of the longitudinal axis of the moving body and also to indicate the distance of the body from the transmitting means and lateral deviation of the body from the predetermined line of travel.

7. A system as claimed in any of claims 1 to 5, in which two additional aerials are provided on the moving body, one on either side of the longitudinal axis thereof, the said aerials being connected to receiving means co-operating with said indicating means for signal radiations transmitted from the given point and received by said additional aerials for

enabling the distance of the body from said transmission means and the lateral deviation of the body from the predetermined line of travel to be ascertained.

8. A system as claimed in claim 6 or 7, in which the indication of distance and of lateral deviation of the body are given by two luminous spots on the screen of a cathode ray tube, said luminous spots being horizontally spaced apart, while the indication of angular displacement of the longitudinal axis of the body is given by a normally central luminous spot which, according to the sense and the amplitude of said angular displacement, is displaced laterally from said central position.

9. A system for detecting angular displacement of the longitudinal axis of a moving body, such as an aeroplane or ship, with respect to a predetermined line of travel toward or away from a given point, comprising radio transmitting means for transmitting synchronously related signal radiations having a variable characteristic from two points symmetrically disposed on either side of the predetermined line of travel, in combination with two longitudinally spaced receiving aerials and receiving means on the moving body connected to the respective aerials, said receiving means co-operating with means for indicating the algebraic difference of the difference of the variable characteristic as received by each aerial from the two points in relation to a time base synchronised with the received signal.

10. A system as claimed in claim 9, in which the synchronously related radiations are frequency modulated, means being provided for measuring the difference of frequencies received by each aerial from the two transmitters simultaneously and means for showing the frequency difference of the said radiations.

11. A system as claimed in claim 9, three independent spaced aerials being provided on the moving body, one of which is located on the longitudinal axis of the body and the others on either side of said axis and having a spacing from said first aerial longitudinally of the body, and means for measuring differences of frequencies received by each aerial from both transmitters simultaneously, means for indicating the angular deviation by measuring the beat frequency received on said aerial on the longitudinal axis of the body and means for utilising said differences of frequency received by the two lateral aerials for

measuring the distance of the body from
the transmission base line and the lateral
displacement of the body from said path.

Dated this 18th day of February, 1949.

MARKS & CLERK.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1952.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which
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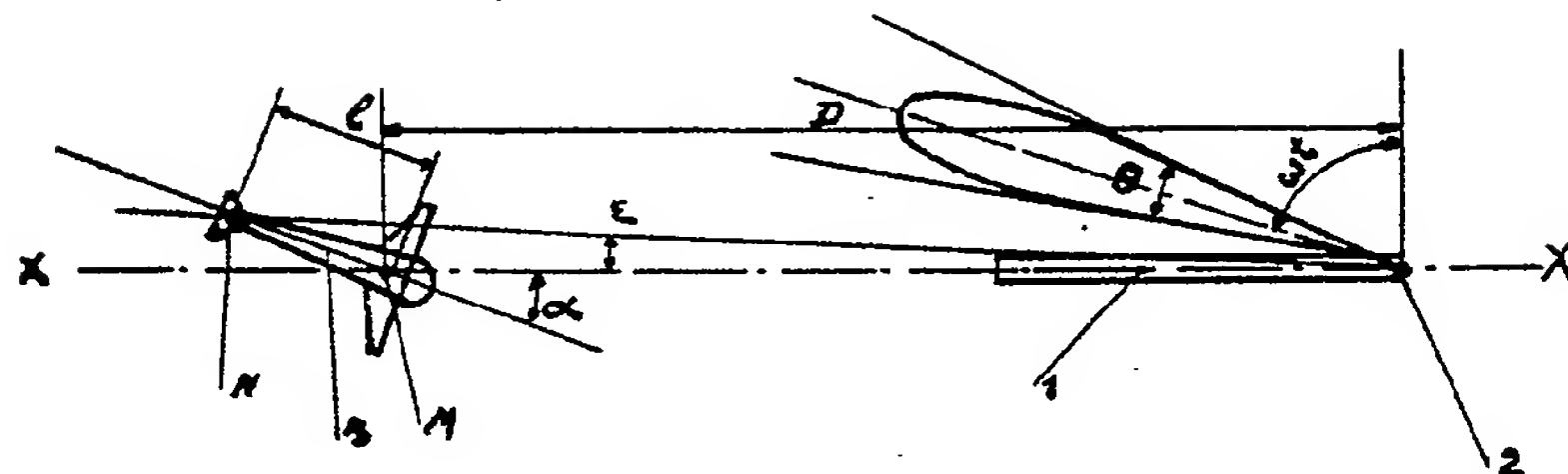


Fig 2

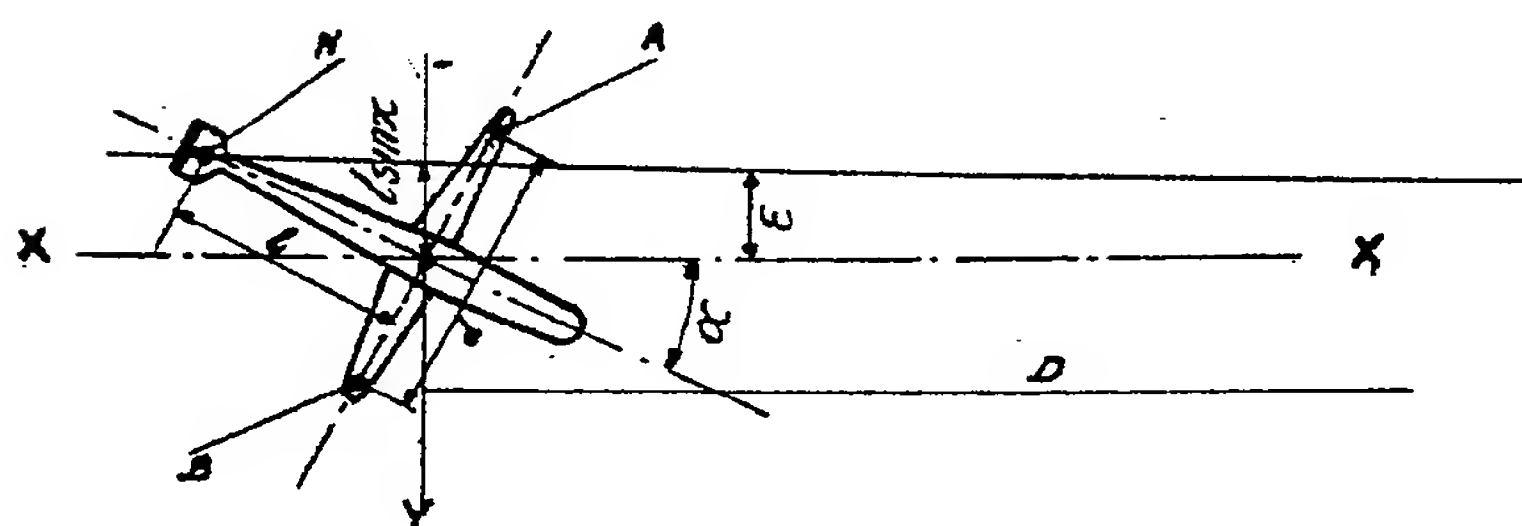
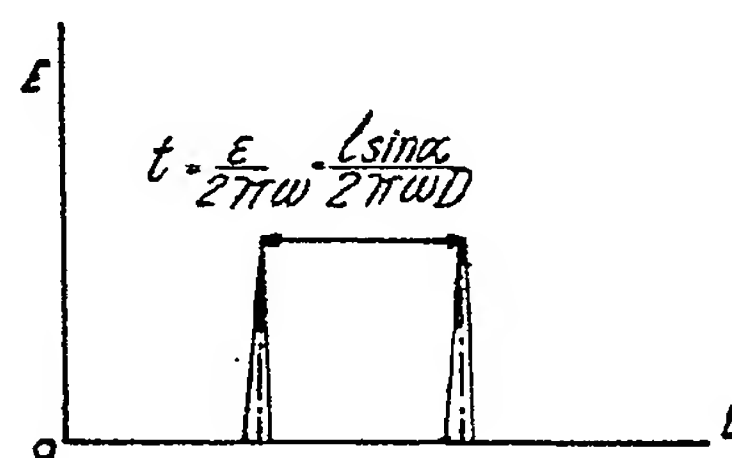


Fig 3



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2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 1 & 2

Fig.5

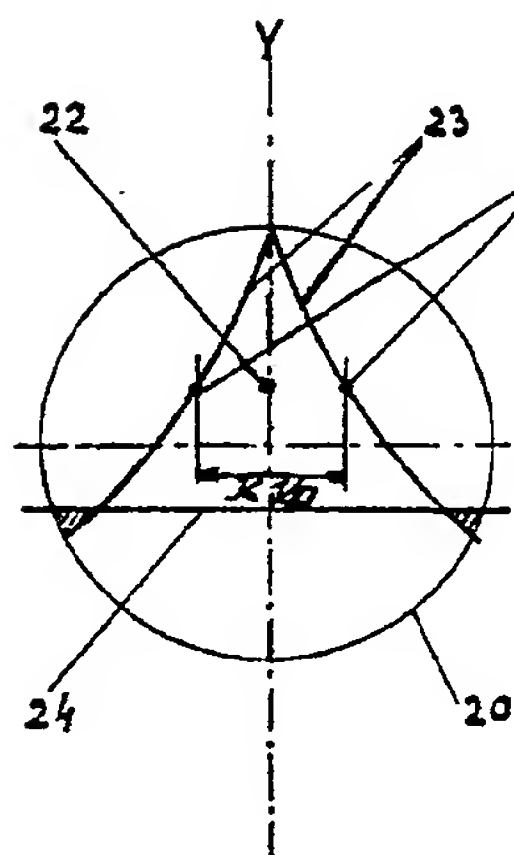


Fig.6.

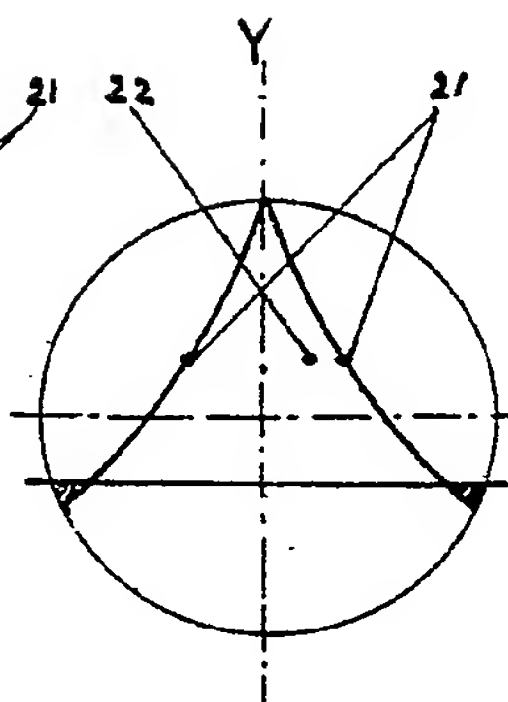


Fig.7

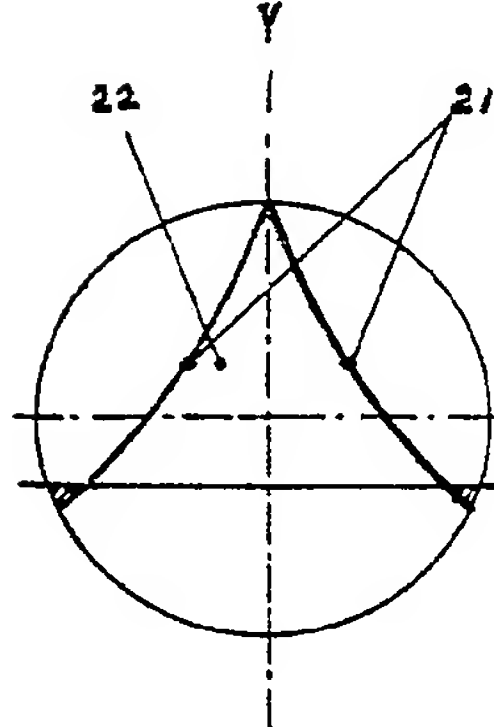


Fig.4

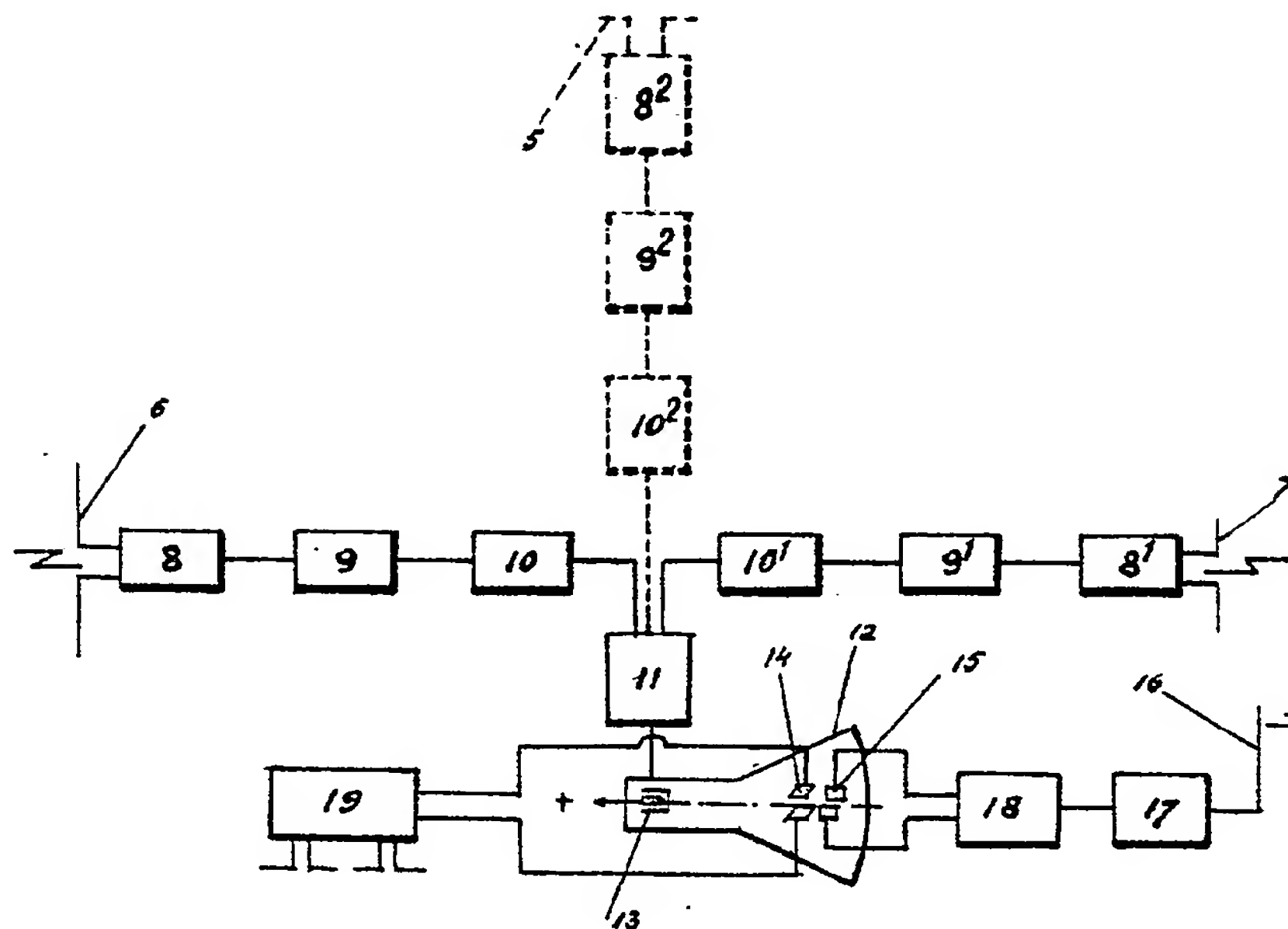


Fig. 1

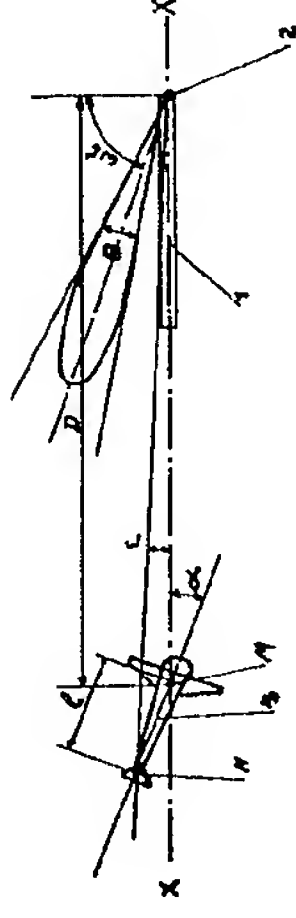


Fig. 2

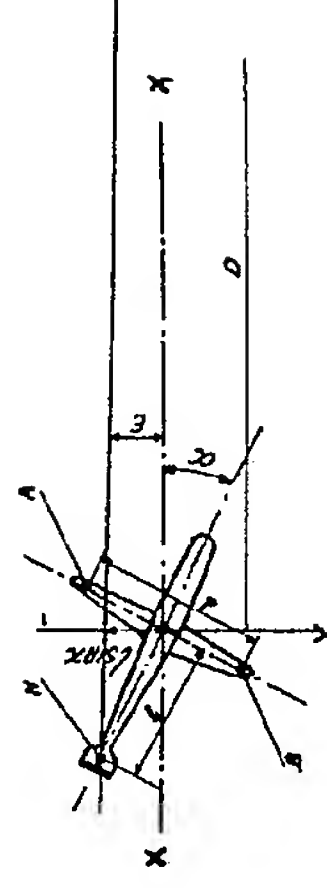


Fig. 3

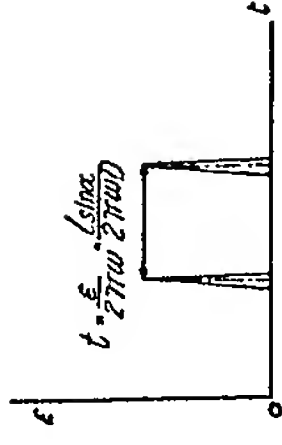


Fig. 5

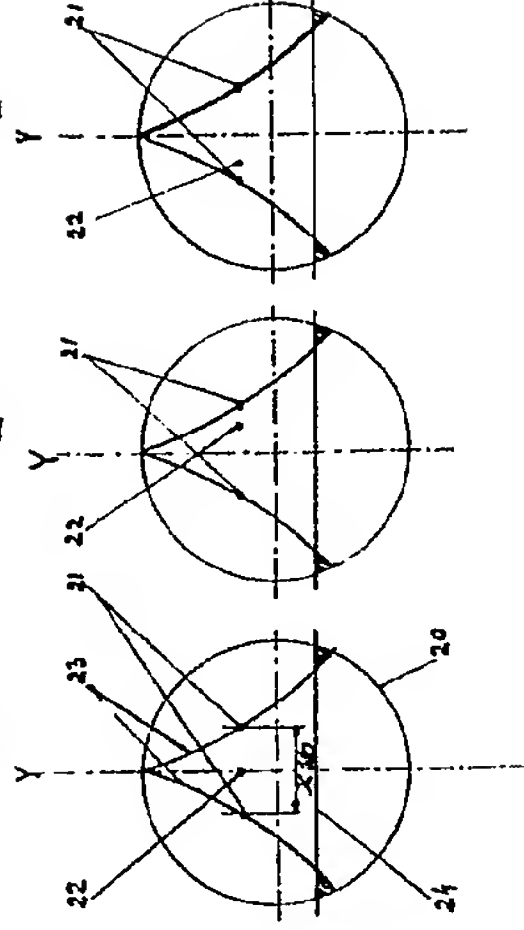


Fig. 6

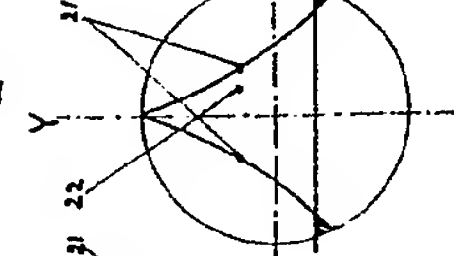


Fig. 7

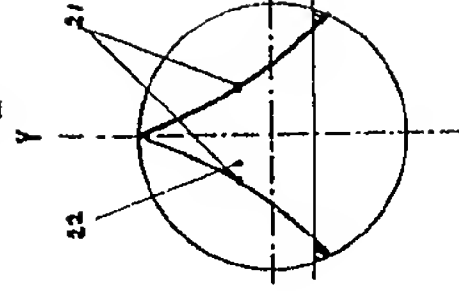


Fig. 4

